APPLICATION OF LSTM FOR APPROXIMATION OF FORCE CHARACTERISTICS OF SPRINGS

V. V. Vlasov, A. R. Einbaum

FSUE «RFNC – VNIITF named after Academ. E. I. Zababakhin», Snezhinsk, Russia

The force characteristic of a spring defines the relationship between deformation and the force required to create it. This paper presents the results of a study on the possibility of approximating the force characteristics of springs to predict their properties during operation. Modeling the object as a whole allows for the description of general patterns that are useful at the design and development stages. However, in real-world operating conditions, a spring can be influenced by numerous factors, such as residual stresses, material inhomogeneity, wear, and others, which complicates the use of analytical models.

Machine learning, particularly deep learning methods such as Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM), offers new opportunities for approximating force characteristics. RNN and LSTM [1] are capable of accounting for data sequences, making them effective for analyzing time series and dependencies, such as changes in force during spring deformation. LSTM networks were developed to address the vanishing gradient problem, which is characteristic of RNNs. This problem arises due to the attenuation of gradients during backpropagation, making model training difficult. LSTM networks use specialized architectures, such as gated memory cells, which allow for efficient processing of temporal dependencies and retention of information about previous system states.

The report presents the results of applying LSTM to approximate the force characteristics of individual springs. Combining multiple springs into packages allows for the management of the overall force characteristic of the entire package. To tune the model for spring packages, measurements from several spring combinations were used, while the total number of combinations allows for the consideration of a larger number of scenarios. The ability to obtain estimates of force characteristics for arbitrary combinations makes it possible to solve the problem of selecting the optimal package composition to achieve the desired force characteristic.

References

1. **Frasconi, P.** Long short-term memory in recurrent neural networks [Text] // International Journal of Engineering and Technolog. – 2003.